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Report May 2021 - High-Resolution 3D Acoustic Borehole Integrity Monitoring

by Cristian Pantea

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Quarterly Research Performance Progress Report

Federal Agency and Organization: Office of Fossil Energy (FE); National Energy Technology Laboratory (NETL); Geologic Storage Technologies

Recipient Organization: Los Alamos National Laboratory

Project Title: High-Resolution 3D Acoustic Borehole Integrity Monitoring, FWP-FE-855-17-FY17

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Project Partners:

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- SNL: Jiann-Cherng Su
- ORNL: Hector Santos-Villalobos
- no cost-sharing partners

DOE Project Team:

DOE Project Officer – Mark Ackiewicz
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Table of Contents

EXECUTIVE SUMMARY

SubTER Topic 1. Wellbore Diagnostics and Integrity Assessment

Real-time, in-situ, high spatial resolution (sub-cm) imaging of the near-borehole environment would revolutionize wellbore diagnostics and integrity assessment by direct observation of defects. It is becoming increasingly apparent, that better understanding of the near-wellbore environment is required to meet the safety and operational needs in challenging environments such as those present in subsurface energy extraction (geothermal) and storage (CO2 sequestration) applications. Therefore, it is important to have a more robust ability to image the near-borehole and reliably detect defects.

It was proposed to further develop and improve our advanced 3D imaging system to evaluate casing defects (e.g. corrosion) and cement quality in either open- or cased-borehole with the ultimate goal to develop a commercially deployable technology. The system consists of a unique acoustic source (LANL) and advanced inversion techniques for image processing (LANL, ORNL). This system will provide comprehensive borehole integrity monitoring with improved resolution over existing techniques. As an application of this imaging system, we will characterize the effectiveness of next-generation wellbore completion technology (NETL, SNL), and will demonstrate that, unlike current technology, the proposed approach can successfully characterize foamed cements.

ACCOMPLISHMENTS & MILESTONE UPDATE

LANL:

We are working on modifying our sensors for fieldwork.

Made several hardware improvements: repaired rotational and vertical translation motors, replaced acoustic directional source, redesigned and rebuilt source holder, and sealed against liquid penetration, replaced defective receivers, cleaned casing on four granite blocks, and tested and characterized all hardware. Several software improvements were performed, such that one can collect data in the field more efficiently. Fully optimized motor movement, by introducing zig-zag pattern that minimizes distance between steps, and full motor reset after each experiment.

The data acquisition software was also rewritten. The data saving option now includes several additional file types, .DAT, .HWS/.HDF5, .TDMS, and the software does no longer require capturing pre-trigger data points. These improvements resulted in much faster data IO (input-output). Additionally, we upgraded to digital triggering utilizing PFI 1 auxiliary line, such that we can now use all 8 analog channels for signal digitization, increased accuracy compared to analog edge triggering, better multi-digitizer synchronization, and capability to move to backplane triggering.

Backend improvements to speed and stability.

ORNL:
ORNL continues development of a model-based image reconstruction technique (MBIR) for ultrasound signals. In contrast to other inversion techniques, ORNL technique maintains a linear model in combination of Gaussian-Markov Random Field prior models to mitigate artifacts resulting from the physical model inaccuracies. This approach allows for image reconstructions at sub-centimeter resolution in near-Realtime, while still competing with the quality of non-linear and full wavefront inversion techniques. The MBIR technique was modified to account for a multi-layered specimen (e.g., water, steel, concrete layers in a well) and take advantage of selected frequencies in the LANL's powerful ultrasound source. By filtering the ultrasound signals at three frequencies and then jointly reconstructing, we remove image artifacts due to incoherence of the ultrasound source and suppress artifacts due to reverberation.

SNL:
The current quarter has focused project management and preparations for the field test. We have extended the period of performance (POP) with New Mexico Tech until 12/31/2021 to allow us to complete the field trials. Our hoist truck is currently being serviced and configured to support the tests and tool deployment. We are also coordinating with the rest of the team on when and how to execute the field tests. Onsite work and travel restrictions will likely push testing into Q3 and beyond.